Italian Botanist 11: 9–30 (2021)
doi: 10.3897/italianbotanist.11.62040
https://italianbotanist.pensoft.net

RESEARCH ARTICLE

Italian Botanist
Published by Società Botanica Italiana

Remnants of naturalness in a reclaimed land of central Italy

Gianmaria Bonari[1], Tiberio Fiaschi[2], Emanuele Fanfarillo[2], Francesco Roma-Marzio[3], Simona Sarmati[2], Enrico Banfi[4], Marco Biagioli[5], Stefan Zerbe[1], Claudia Angiolini[2]

1 *Faculty of Science and Technology, Free University of Bozen-Bolzano, Piazza Università 5, 39100, Bolzano, Italy* **2** *Department of Life Sciences, University of Siena, Via P.A. Mattioli 4, 53100, Siena, Italy* **3** *Orto e Museo Botanico, Sistema Museale di Ateneo, University of Pisa, Via Luca Ghini 13, 56126, Pisa, Italy* **4** *Sezione di Botanica, Museo di Storia Naturale di Milano, Corso Venezia 55, 20121, Milano, Italy* **5** *Meteo Siena 24, Via Piave 2, 53100, Siena, Italy*

Corresponding author: Emanuele Fanfarillo (emanuele.fanfarillo@unisi.it)

Academic editor: L. Peruzzi | Received 14 December 2020 | Accepted 12 January 2021 | Published 29 January 2021

Citation: Bonari G, Fiaschi T, Fanfarillo E, Roma-Marzio F, Sarmati S, Banfi E, Biagioli M, Zerbe S, Angiolini C (2021) Remnants of naturalness in a reclaimed land of central Italy. Italian Botanist 11: 9–30. https://doi.org/10.3897/italianbotanist.11.62040

Abstract

Wetlands are among the most fragile habitats on Earth and have often undergone major environmental changes. As a study case in this context, the present work aims at increasing the floristic knowledge of a reclaimed land now turned into an agricultural lowland with scarce patches of natural habitats. The study area is named Piana di Rosia, and it is located in southern Tuscany (Italy). The compiled checklist consists of 451 specific and subspecific taxa of vascular plants. The life-form spectrum shows a predominance of hemicryptophytes, followed by therophytes. The chorological spectrum highlights a co-dominance of Euri-Mediterranean and Eurasian species along with many widely distributed species. The checklist includes seven species of conservation concern, three Italian endemics (*Crocus etruscus* Parl., *Polygala vulgaris* L. subsp. *valdarnensis* (Fiori) Arrigoni, and *Scabiosa uniseta* Savi), 41 alien species, 21 segetal species, and 11 aquatic macrophytes of which five helophytes and six hydrophytes. This study suggests that irreversible land-use changes in wetlands can lead towards a simplification of the flora. However, despite the deep transformations that the former wetland has undergone, the presence of some aquatic and protected taxa is interesting. From a conservation point of view, the natural value of this agricultural area could be enhanced and its current management partly reconsidered, thus preserving the remnants of naturalness present.

Keywords

Agroecosystem, biodiversity, botany, checklist, inventory, phytogeography, SAR, survey, wetland

Copyright *Gianmaria Bonari et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Introduction

Wetlands are acknowledged to be among the most biologically productive ecosystems (Ramsar Convention on Wetlands 2018). They play a major role in the water cycle by receiving, storing and releasing water, regulating flows, and supporting life. River channels, floodplains and connected wetlands play a significant role in hydrology. Wetlands work as natural sponges that trap and slowly release surface water, rain, snowmelt, groundwater, and floodwaters. Besides, their holding capacity helps to control floods and prevents water logging of crops (Environmental Protection Agency 2020). Moreover, wetlands contribute to the regulation of microclimate, while wetland vegetation slows the speed of floodwaters and helps in distributing them over the floodplain.

In the Mediterranean Basin, natural wetland habitats decreased in extension by 10% between 1975 and 2005 (Mediterranean Wetlands Observatory 2014). This loss is mainly due to land conversion to agricultural land-use and urbanization (Gardner et al. 2015). Land-use changes and the implementation of artificial water systems have reduced the connectivity in many river systems and floodplain wetlands (Ramsar Convention on Wetlands 2018). The environmental changes that wetlands underwent during the last century significantly depleted their unique biodiversity. Furthermore, human activities often simplified geomorphology, eliminating important environments such as transitional ones that connect wetlands and dryer areas, whose flora and fauna are among the most threatened (Alessandrini 2000).

In Europe, the loss of wetland biodiversity is a consequence of the declining extent and quality of wetland habitats (Janssen et al. 2016). However, in Italy, freshwaters host many threatened species and habitats (Gigante et al. 2016, 2018; Orsenigo et al. 2020). Consistently with the general trends at larger scales, also many wetlands of southern Tuscany have suffered a decrease in extent. Such reduction has generally caused an overall decline in plant diversity, with the disappearance of native species and an increase of non-native ones (Viciani et al. 2014; Lazzaro et al. 2020; Viciani et al. 2020).

This study concerns a lowland known as Piana di Rosia, located a few kilometers southwest of Siena (Tuscany, central Italy). This former wetland turned into an intensive agricultural area in the 19th century. Though, land-use change and human impact led to a substantial loss of the humid habitats, relict elements of naturalness, related to more or less humid environments, are present.

In Tuscany, information at the species level is usually easily available as it is embedded in floristic online databases (i.e., Wikiplantbase #Toscana – Peruzzi and Bedini 2015 onwards; Peruzzi et al. 2017a), where data arising from studies on a different scale (Arrigoni 2016–2018; Bonari et al. 2016–2019; Cannucci et al. 2019), as well as herbarium specimens and field observations, are stored. This data availability has also facilitated the study of the patterns of Tuscan floristic richness (D'Antraccoli et al. 2019). However, unlike many well-studied neighbouring areas (Mariotti et al. 1986; Chiarucci et al. 1993; Landi et al. 2002, 2009, 2016), floristic knowledge of the Piana di Rosia is very scarce (Angiolini et al. 2005), except for some recent floristic findings

(Peruzzi et al. 2017b, 2017c, 2018). Also, only a few herbarium samples and a few literature sources can testify for the diversity of aquatic plants once present (Caruel 1860; Baroni 1908). Therefore, we aim at increasing the floristic knowledge of southern Tuscany in the context of a transformed landscape by providing an inventory of the vascular plants of the Piana di Rosia.

Materials and methods

Study area

The Piana di Rosia is a lowland plain of central Italy that covers 23.23 km^2 and is located about 10 km southwest of Siena (southern Tuscany, 43°14'38"N, 11°15'35"E). The average elevation is 190 m a.s.l., ranging between 180 and 250 m a.s.l. The area lies within the municipality of Sovicille, in the administrative province of Siena, and is surrounded by small villages (Fig. 1).

The study area borders the Special Area of Conservation (SAC) "Montagnola Senese" (IT5190003) along its western side, and the SAC "Alta Val di Merse" (IT519006) along its southwestern side. The Nature Reserve "Alto Merse" is also nearby present (in Suppl. material 1: Fig. S1).

The study area is dominated by alluvial and lake deposits. The alluvial deposits occur in the central and southern part and have a mainly gravelly and/or sandy texture. Lake sediments occur along the borders of the study area, at slightly higher elevations. In the eastern part, eluvian-colluvial deposits occur. In the northeastern part, where superficial deposits are missing, marine Pliocene deposits emerge (mudstones and sandstones). An outcrop of Miocene continental breccia (limestone) is present near the village of Malignano (Martini 2011; Iacoviello and Martini 2012, 2013). The study area is part of a wide aquifer (Luco aquifer), which extends northwards between the Montagnola Senese area, Pian del Lago area, and the village of Monteriggioni. The aquifer mainly develops within the Breccia di Grotti Formation (Barazzuoli et al. 2020).

The bioclimate of the study area can be classified as Oceanic sub-Mediterranean (Temperate sub-Mediterranean macrobioclimate). The thermotype is lower mesotemperate and the ombrotype is upper sub-humid. Regarding the continentality, the climate is weakly semi-continental (Pesaresi et al. 2014, 2017). The position of the plain surrounded by hills enhances temperature excursions, both daily and seasonal. According to the nearby weather station of San Rocco a Pilli, in the period 2008–2018 the mean annual temperature was 14.3 °C. January was the coldest month (mean temperature 5.3 °C) and July the hottest month (24.2 °C). Freezing temperatures are common in winter, due to thermal inversion. The recorded temperature extremes are about -10 °C and 40 °C. According to the nearby weather station of Rosia, in the period 1951–1997 the mean annual rainfall was 962 mm. Summer was the driest season (125 mm) and winter the wettest one (252 mm).

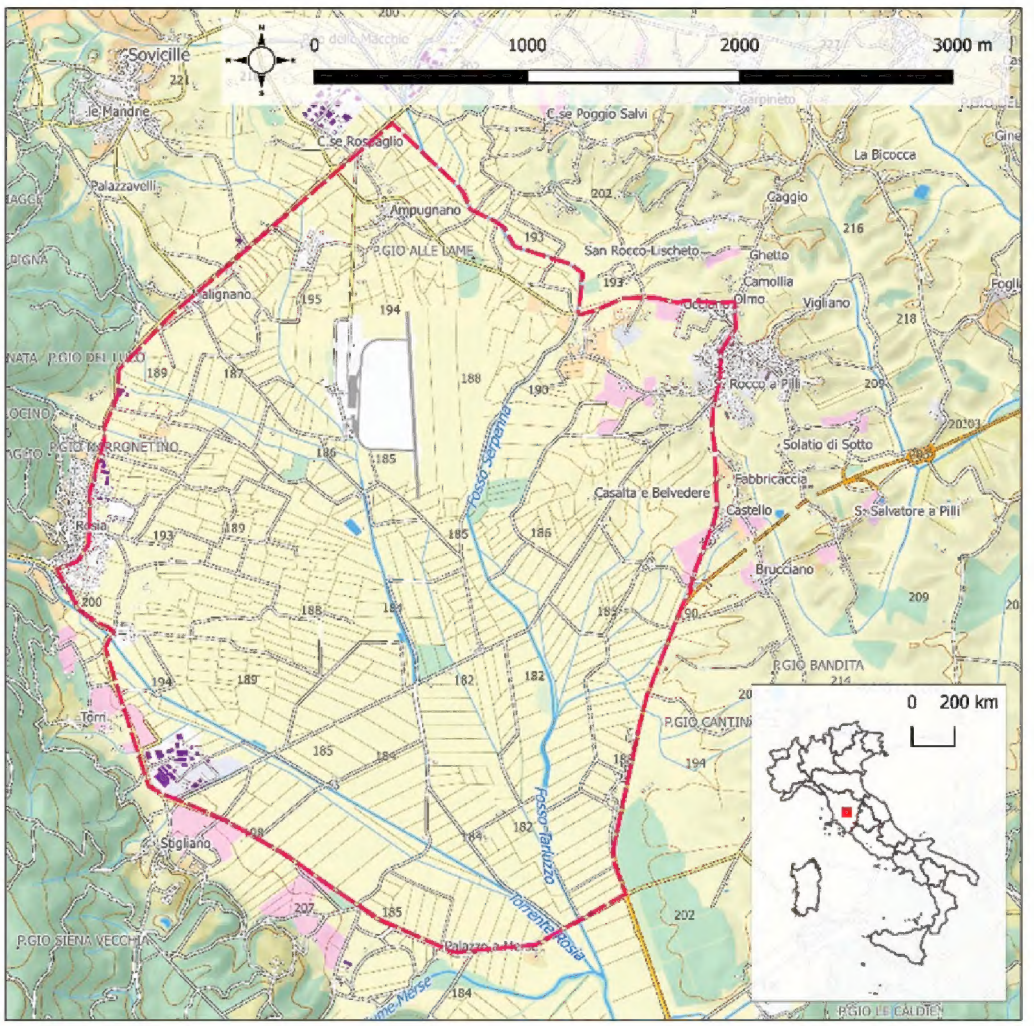

Figure 1. Borders of the study area (red dashed line) and, in the box, the location of the Piana di Rosia (Sovicille, Siena) in Italy.

Landscape transformation

The Piana di Rosia was formerly an ancient wetland reclaimed in the 19th century for agricultural purposes. The plain was neither included in the existing inventory of the marshy areas of Tuscany (Arrigoni 1981), nor in the review on the status of geobotanical knowledge of the Tuscan wetlands (Tomei 1982). This testifies that the landscape has been heavily modified and cannot be considered a wetland anymore. The wetland extended along the middle course of the Merse River and some of its tributaries (Favilli et al. 2017). Like elsewhere in Italy, in the 1950s traditional agro-pastoral practices began to be gradually replaced by intensive agriculture. This led to the disappearance of the traditional agricultural landscape, highly diversified and hosting frequent patches of natural and semi-natural vegetation, with a shift towards a simplified agro-ecosystem represented by large arable fields and artificial water channels (Suppl. material 1: Fig. S2). Unlike other lowlands of the Siena territory, Piana di Rosia was cultivated already in the first half of the nineteenth century (Greppi 2014). In the last decades, this territory is experiencing a phase of 'attrition', a stage in the process of fragmentation when only very small and isolated patches of natural vegetation remain (Hunter and Gibbs 2007). Elements such as riparian woods, swampy areas, shrublands, and grasslands, are present (Fig. 2).

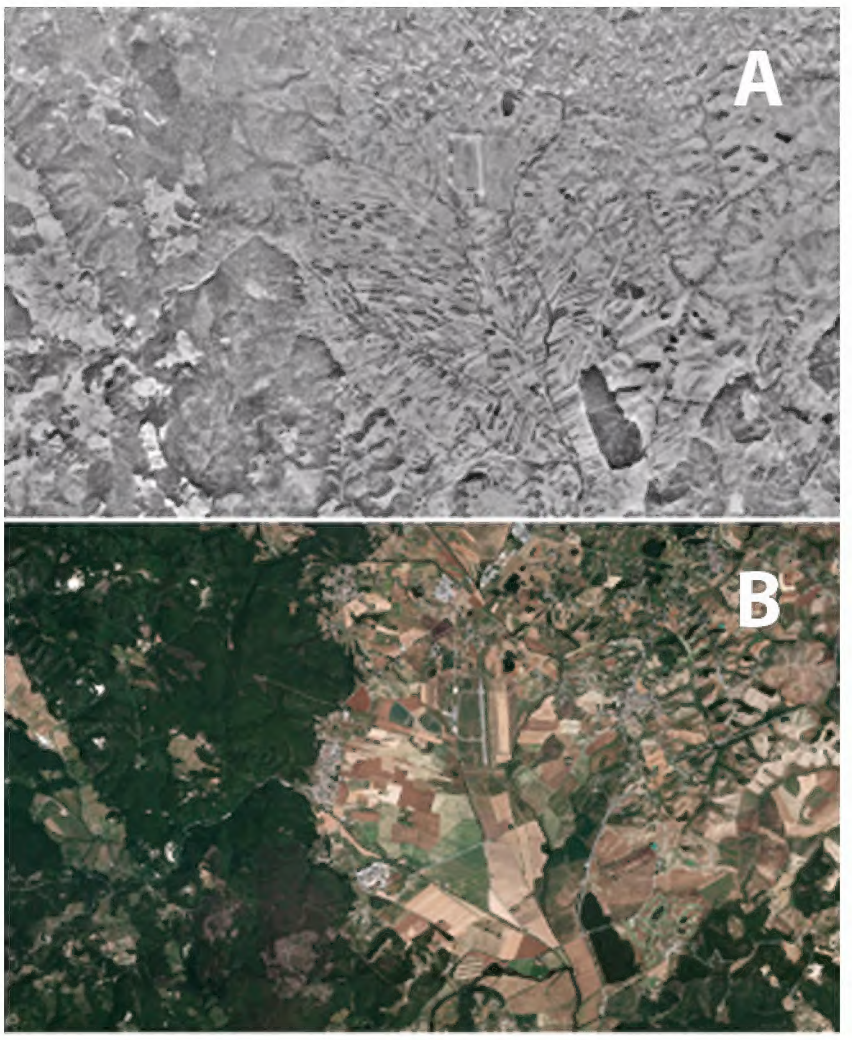

Figure 2. Aerial photos of the study area in 1954 (**A**) and 2019 (**B**), showing the intensification of the agricultural practices, thus resulting in larger and more homogeneous patches (Regione Toscana 2020).

Current land-use types

The main land-use types in the study area derive from thematic maps of Regione Toscana (2020) (Suppl. material 1: Fig. S3). About 90% of the study area is devoted to agricultural land use. Arable crops are the main ones, including winter cereals (mainly *Triticum* sp. pl.), corn (*Zea mays* L.), sunflower (*Helianthus annuus* L.), and sorghum (*Sorghum bicolor* (L.) Moench). Woody crops are much less common and include olive groves (*Olea europaea* L.), walnut groves (*Juglans regia* L.) and vineyards (*Vitis vinifera* L.). The rest is occupied by urban and industrial areas (6.0%), broad-leaved forests (1.6%), an airport (1.0%), transitional forest-shrub formations (0.9%), and inland waters (0.04%). The latter include small lakes and main streams, but not artificial channels, which are mapped as deciduous or transitional shrubs.

Field surveys and data analysis

We carried out floristic surveys from 2017 to 2019 in all the land-use types, but excluding urban and industrial areas, with the exception of the airport area, that are limited in extension and out of our aim. The investigations were performed in all seasons. The collected specimens are stored in the herbarium SIENA (acronym follows Thiers 2020 onwards). Species were mainly identified according to Pignatti (1982), Pignatti et al.

(2017–2019), and occasionally by using Fiori (1923–1929). We used other floras or specific publications for critical groups including Tutin et al. (1964–1980), Castroviejo et al. (1984–2005), Rameau et al. (1989, 2008), Tison and De Foucault (2014), Arrigoni (2014–2018), Di Natale et al. (2020). Taxonomic nomenclature follows the updated Italian checklists of the native (Bartolucci et al. 2018a) and alien (Galasso et al. 2018a) vascular flora and subsequent updates summarised in the Portal to the Flora of Italy (2020 onwards; see also Martellos et al. 2020). The order of families follows Bartolucci et al. (2018a) and Galasso et al. (2018a), whereas species are arranged in alphabetical order.

To highlight chorological novelties, we checked species distribution at the administrative province, region and national levels (Peruzzi and Bedini 2015 onwards; Portal to the Flora of Italy 2020). To verify the conservation concern of each taxon, we checked the Tuscan attention list, the Italian and European Red Lists of vascular plants, the list of rare or threatened European arable plants, and the IUCN Red List of threatened species (Sposimo and Castelli 2005; Bilz et al. 2011; Castelli 2012; Rossi et al. 2013; Storkey et al. 2012; Orsenigo et al. 2020; IUCN 2021). We detected Italian endemic taxa according to Bartolucci et al. (2018a, b, c). Alien species, their introduction time in Italy, and naturalization status categories in the study area follow Galasso et al. (2018a, b, c). With regard to the alien status, we distinguished three categories, i.e., casual (unable to form self-maintaining populations), naturalized (occurring with self-maintaining populations), and invasive (occurring with self-maintaining populations and being able to spread over a large area) (Galasso et al. 2018a). Concerning the introduction time, we distinguished between archaeophytes, introduced before 1492, and neophytes, introduced after 1492 (Galasso et al. 2018a). Since Piana di Rosia is an agricultural area, we checked segetal species, i.e., typical "weeds" of wheat and similar crops, following Fanfarillo et al. (2020a). Within segetal species, we checked the presence of strictly segetal species, i.e., those species strictly dependent on such crops. Life forms and chorotypes follow Pignatti (1982), with the exception of alien species (Galasso et al. 2018a, b, c).

Finally, we calculated a Species-Area Relationship (SAR) strictly based on the extension of the study area according to the formula proposed by D'Antraccoli et al. (2019). This formula provides constants for Tuscany that allow to calculate the expected species in an area. We calculated the expected number of species for all taxa, native taxa and alien taxa.

Graphs were drawn using R Studio v. 3.6.0 (R Core Team 2020).

Results

Floristic inventory

The floristic checklist includes 451 specific and subspecific taxa for the study area (Suppl. material 1: Floristic inventory). The taxa belong to 283 genera and 75 families. We recorded 442 Angiosperms, eight fern and fern allies, and one gymnosperm (*Juniperus communis* L.).

According to the SAR formula, we obtained -31.4% of taxa compared to the expected value of 654 and -36.5% for native taxa compared to the expected value of 644. On the contrary, concerning alien species, we obtained +45.2% of taxa compared to the expected value of 29. The most represented families are Poaceae (63 taxa), Asteraceae (53), and Fabaceae (40) (Fig. 3). The most represented genera are *Euphorbia* and *Lathyrus* (8 taxa), *Trifolium* (7), *Galium* (6), *Carex*, *Festuca*, *Geranium*, *Veronica*, and *Vicia* (5).

Overall, we found seven species of conservation concern. One species (*Crocus etruscus* Parl.) is included in the IUCN Red List of threatened species and in the European Red List of vascular plants, as Near Threatened, in the Tuscan attention list, and in Annex IV of the Habitat Directive (Bilz et al. 2011; Carta and Peruzzi 2011; Ercole et al. 2016). The species included in the Red Lists of threatened vascular plants of Italy are six, five of which are classified as Least Concern (*Allium pendulinum* Ten., *Bellevalia romana* (L.) Sweet, *Brachypodium phoenicoides* (L.) Roem. & Schult., *Ruscus aculeatus* L., and *Thinopyrum acutum* (DC.) Banfi), and one as Data Deficient (*Cirsium vulgare* (Savi) Ten. subsp. *vulgare*).

We found 10 native taxa that are new or confirmed for the administrative province of Siena: *Allium rotundum* L., *Brachypodium phoenicoides* (L.) Roem. & Schult., *Bromus racemosus* L., *Dasypyrum villosum* (L.) P.Candargy, *Eragrostis pilosa* (L.) P.Beauv. subsp. *pilosa*, *Fragaria viridis* Weston subsp. *viridis*, *Medicago praecox* DC., *Persicaria decipiens* (R.Br.) K.L.Wilson, *Populus canescens* (Aiton) Sm., and *Spergularia rubra* (L.) J.Presl & C. Presl. We found three native taxa with no records in the last century for the administrative province of Siena. These are *Allium longispathum* Redouté, *Bromus commutatus* Schrad. subsp. *commutatus*, and *Persicaria maculosa* Gray. Eight alien taxa are new to the administrative province of Siena: *Amaranthus hybridus* subsp. *cruentus* (L.) Thell., *A. powellii* S.Watson, *Beta vulgaris* L. subsp. *vulgaris*, *Oxalis articulata* Savigny, *Panicum miliaceum* L. subsp. *miliaceum*, *Parthenocissus quinquefolia* (L.) Planch., *Sporobolus indicus* (L.) R.Br., and *Vitis* × *koberi* Ardenghi, Galasso, Banfi & Lastrucci. With regard to *Amaranthus hybridus* subsp. *cruentus* (L.) Thell., several historical specimens are present in SIENA, but many of these specimens were collected at the Botanical Garden of Siena with no clear indication as to whether they were cultivated plants or not, whereas others have no locality.

We found 16 rare native taxa that represent the second or third recent record in the administrative province of Siena. They are *Brassica nigra* (L.) W.D.J.Koch, *Conium maculatum* L. subsp. *maculatum*, *Glyceria fluitans* (L.) R.Br., *Hordeum geniculatum* All., *H. marinum* Huds., *Lythrum tribracteatum* Salzm. ex Spreng., *Orobanche caryophyllacea* Sm., *O. crenata* Forssk., *Polygonum arenastrum* Boreau, *Raphanus raphanistrum* subsp. *landra* (Moretti ex DC.) Bonnier & Layens, *Stachys annua* (L.) L. subsp. *annua*, *S. palustris* L., *Thalictrum minus* L. subsp. *minus*, *Tordylium maximum* L., *Veronica cymbalaria* Bodard subsp. *cymbalaria*, and *Visnaga daucoides* Gaertn.

Of the 41 alien species, 30 are neophytes and 11 are archaeophytes. Neophytes are *Actinidia deliciosa* (A.Chev.) C.F.Liang & A.R.Ferguson, *Ailanthus altissima* (Mill.) Swingle, *Amaranthus deflexus* L., *A. hybridus* subsp. *cruentus*, (L.) Thell. *A. powellii* S.Watson, *A. retroflexus* L., *Artemisia verlotiorum* Lamotte, *Bidens frondosa* L., *Crepis*

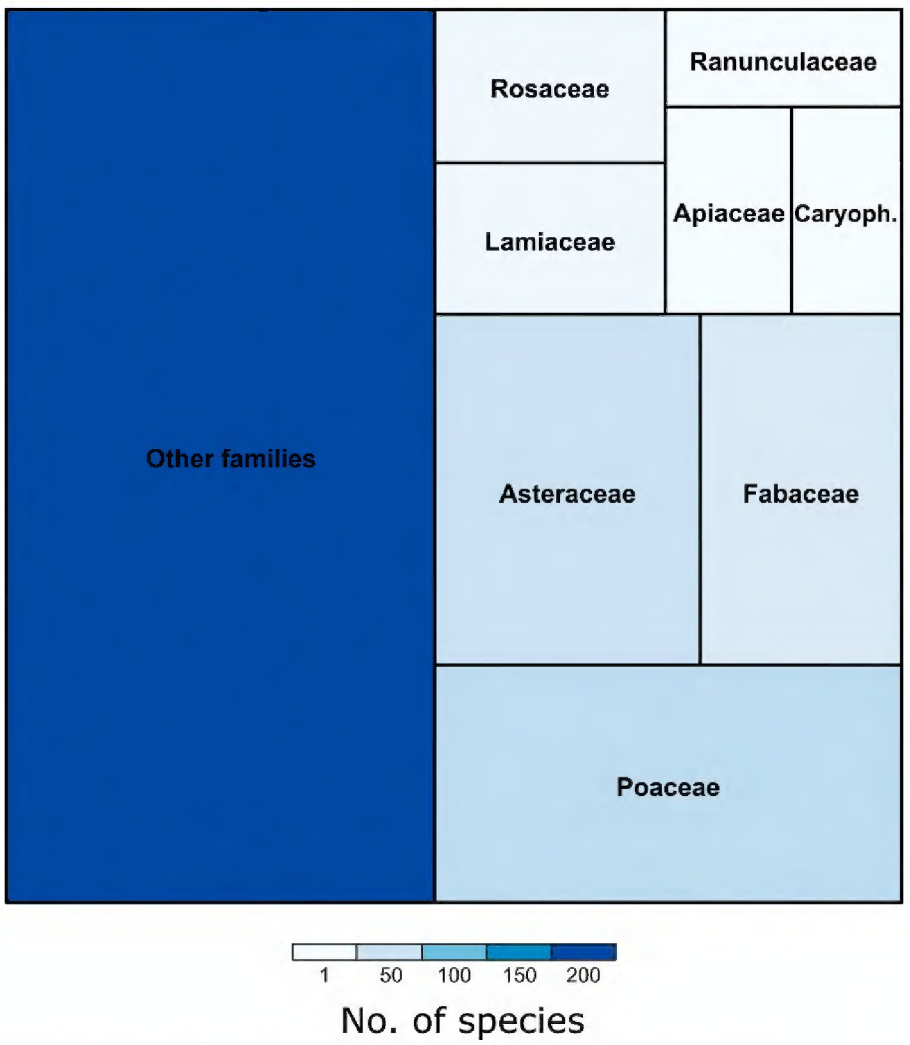

Figure 3. Representation of the families across the inventoried flora. Each rectangle represents a family. The area of each polygon is proportional to the number of taxa present in the given category. Other families = families with less than 12 species; Caryoph. = Caryophyllaceae.

sancta (L.) Bornm. subsp. *nemausensis* (P.Fourn.) Babc., *Cuscuta campestris* Yunck., *Datura stramonium* L., *Erigeron annuus* (L.) Desf., *E. bonariensis* L., *E. canadensis* L., *E. sumatrensis* Retz., *Euphorbia maculata* L., *E. prostrata* Aiton, *Fagopyrum esculentum* Moench, *Helianthus tuberosus* L., *Mirabilis jalapa* L., *Oxalis articulata* Savigny, *Parthenocissus quinquefolia* (L.) Planch., *Paspalum distichum* L., *Robinia pseudoacacia* L., *Setaria italica* (L.) P.Beauv., *Sporobolus indicus* (L.) R.Br., *Veronica persica* Poir., *Vitis riparia* Michx., *Vitis* × *koberi* Ardenghi, Galasso, Banfi & Lastrucci, and *Xanthium italicum* Moretti. Archaeophytes are *Abutilon theophrasti* Medik., *Arundo donax* L., *Avena fatua* L. subsp. *fatua*, *Beta vulgaris* L. subsp. *vulgaris*, *Galega officinalis* L., *Hordeum vulgare* L. subsp. *vulgare*, *Isatis tinctoria* L. subsp. *tinctoria*, *Medicago sativa* L., *Mespilus germanica* L., *Panicum miliaceum* L. subsp. *miliaceum*, and *Sorghum halepense* (L.) Pers. In the study area, the naturalization status for alien species is thus distributed: six taxa are casual, 20 are invasive, and 15 are naturalized.

We found 21 segetal taxa in the study area. Among the segetal species, four are strictly segetal, i.e., strictly related to wheat fields and similar habitats, and they are *Alopecurus myosuroides* Huds. subsp. *myosuroides*, *Bunium bulbocastanum* L., *Delphinium consolida* L. subsp. *consolida*, and *Legousia speculum-veneris* (L.) *Chaix* subsp. *speculum-veneris*, the latter being the only segetal species of conservation concern in

Europe. The other species are typical for segetal habitats, but commonly occur also in other open and more or less disturbed habitats: *Anisantha diandra* (Roth) Tutin ex Tzvelev, *Avena fatua* L. subsp. *fatua*, *Brassica nigra* (L.) W.D.J.Koch, *Euphorbia exigua* L. subsp. *exigua*, *E. falcata* L. subsp. *falcata*, *Gladiolus italicus* Mill., *Lathyrus annuus* L., *Lysimachia arvensis* (L.) U.Manns & Anderb. subsp. *arvensis*, *Matricaria chamomilla* L., *Muscari comosum* (L.) Mill., *Myosotis arvensis* (L.) Hill subsp. *arvensis*, *Orobanche crenata* Forssk., *Papaver rhoeas* L. subsp. *rhoeas*, *Rapistrum rugosum* (L.) All., *Sinapis arvensis* L. subsp. *arvensis*, *Veronica arvensis* L., and *Vicia angustifolia* L.

Eleven aquatic vascular plant species were recorded, including five helophytes and six hydrophytes. The helophytes are *Carex pendula* Huds., *Cyperus longus* L., *Lythrum salicaria* L., *Phragmites australis* (Cav.) Trin. ex Steud., and *Schoenoplectus lacustris* (L.) Palla, while the hydrophytes are *Alisma plantago-aquatica* L., *Callitriche stagnalis* Scop., *Glyceria fluitans* (L.) R.Br., *Lemna minor* L., *Potamogeton polygonifolius* Pourr., and *Sparganium neglectum* Beeby.

Life-form spectrum

The life-form spectrum shows a predominance of herbaceous taxa, mostly hemicryptophytes (35.9%) and therophytes (30.8%) (Fig. 4).

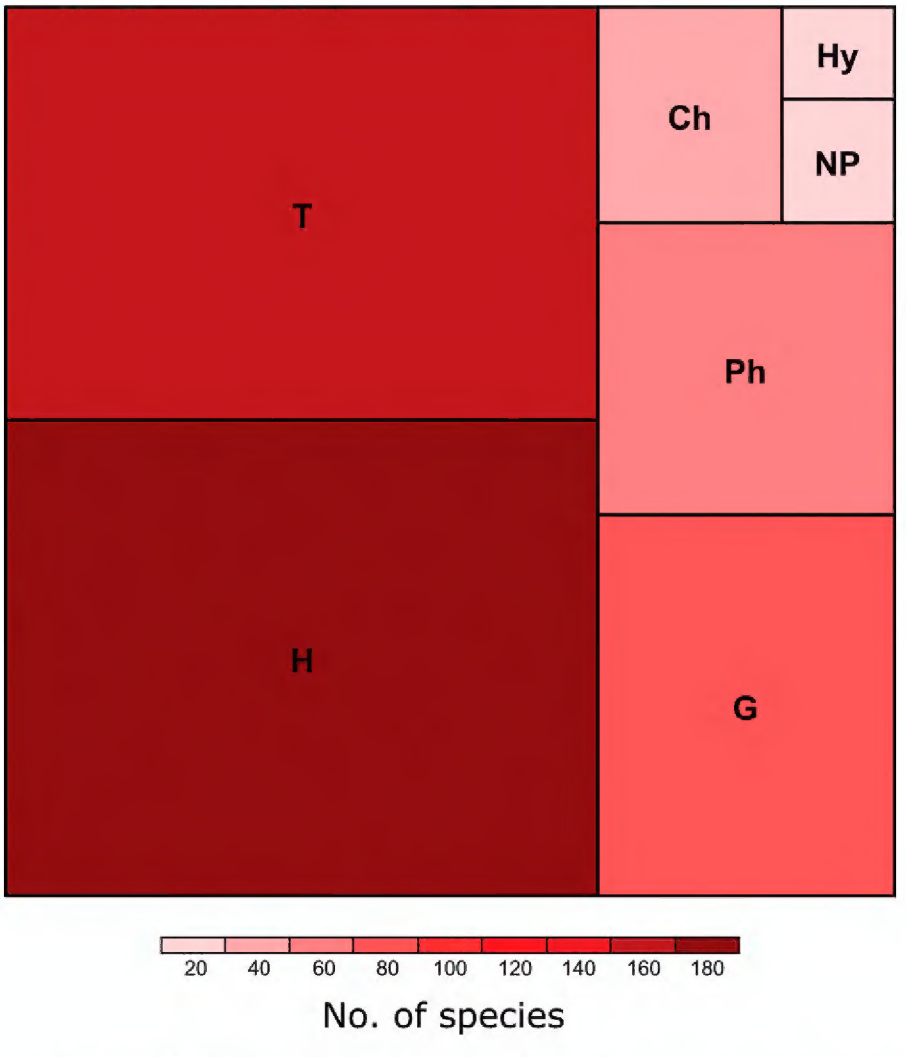

Figure 4. Life-form spectrum of the inventoried flora. Ch = chamaephytes; G = geophytes; H = hemicryptophytes; Hy = hydrophytes; NP = nanophanerophytes; Ph = phanerophytes; T = therophytes. The area of each polygon is proportional to the number of taxa present in the given category.

Chorological spectrum

The chorological spectrum shows a co-dominance Mediterranean (27.1%) and Eurasian (23.5%) elements (Fig. 5).

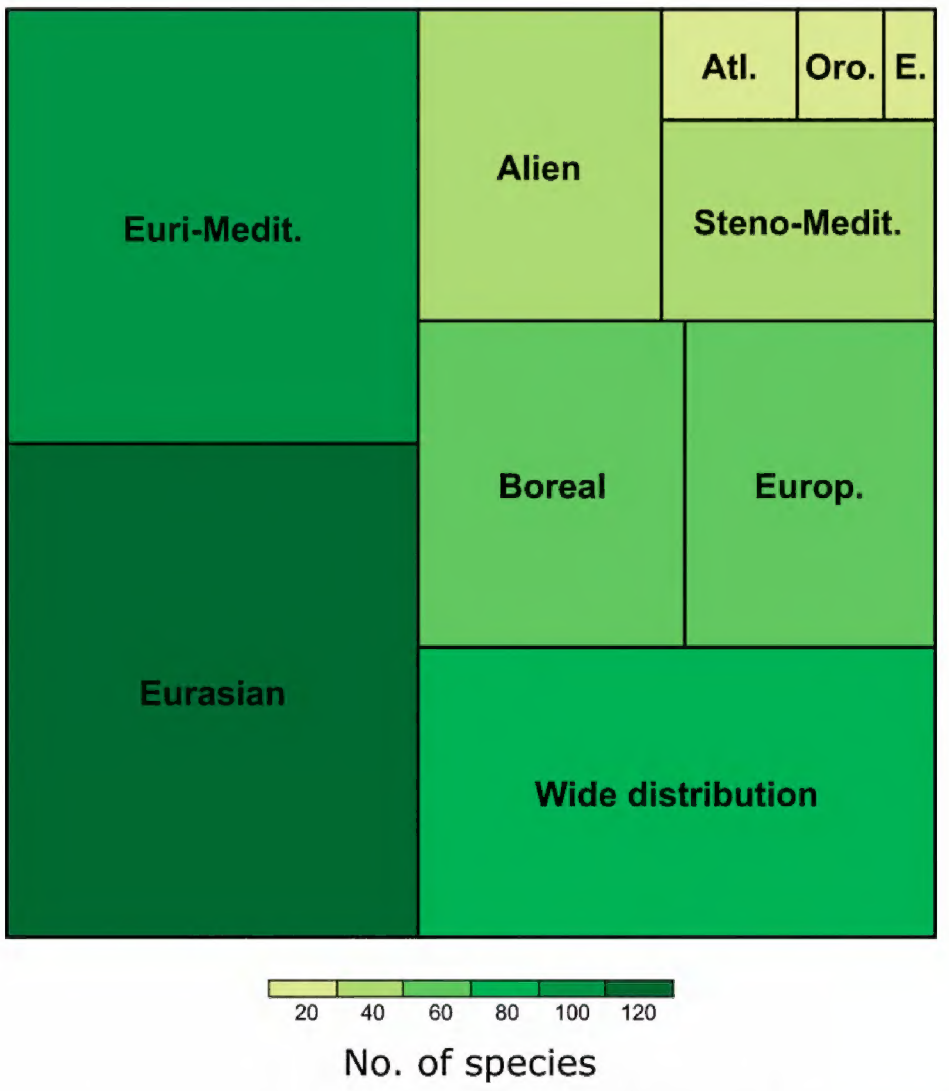

Figure 5. Chorological spectrum of the inventoried flora. Atl. = Atlantic; E. = Italian endemics; Euri-Medit. = Euri-Mediterranean; Europ. = European; Oro. = Orophilous; Steno-Medit. = Steno-Mediterranean. The area of each polygon is proportional to the number of taxa present in the given category.

Discussion

We studied a reclaimed land of central Italy that is currently an agricultural area. Our floristic surveys revealed the presence of a relatively rich vascular flora in the study area, thanks to the diversity of the habitats present, although most of them occur as small patches. In particular, wetlands and relict woods represent the most relevant elements. Therefore, our results suggest that, despite the conversion to agricultural land, former wetlands host particular species, especially in particular remnant habitats.

The abundance of Poaceae, Asteraceae, and Fabaceae is similar but not consistent with the pattern known for the Italian flora, as the abundance of the first two families in the Italian flora is reversed. The families with fewer species largely follow the trend of the Italian flora (Bartolucci et al. 2018a; Galasso et al. 2018a).

The high proportion of annual species, mostly linked to non-hygrophilous communities as found by Angiolini et al. (2011), is related to the large surfaces used as agricultural areas, especially as arable land. The repeated tillage and the disturbance of the sites promotes therophytes in arable crop fields (Fanfarillo et al. 2020a). Though forests and shrublands are generally rare in the area, we found a relatively high diversity of phanerophytes and nanophanerophytes. The abundance of geophytes is partly related to residual natural and semi-natural habitats (e.g., *Anemonoides nemorosa* (L.) Holub, *Petasites hybridus* (L.) G.Gaertn., B.Mey. & Scherb. subsp. *hybridus*), but also promoted by tillage practices as reflected by species as *Cirsium arvense* (L.) Scop., *Gladiolus italicus* Mill., and *Sorghum halepense* (L.) Pers.). On the contrary, we recorded only few aquatic species due to the limited surfaces of wetlands, nowadays corresponding to artificial water bodies and channels, which, especially these latter, tend to dry out in summer. However, species related to wet or partially wet environments are present, such as *Althaea cannabina* L., *Lysimachia nummularia* L., *Lythrum tribracteatum* Salzm. ex Spreng., and *Sparganium neglectum* Beeby. This is in accordance with other Tuscan wetlands under a strong anthropogenic pressure (Lastrucci et al. 2010, 2014). Palustrine and lacustrine plants and plant communities might respond differently to different environmental factors (Angiolini et al. 2019).

The chorological spectrum is in line with the life-form spectrum, highlighting a transition between the Mediterranean and Temperate climate. Both, European and Mediterranean species are abundant, with a slight predominance of the former. The high number of widely distributed species is largely due to the occurrence of synanthropic plants (e.g., *Alopecurus myosuroides* Huds. subsp. *myosuroides*, *Chenopodium album* L. subsp. *album*, and *Poa annua* L.) and only partially to aquatic plants (e.g., *Alisma plantago-aquatica* L., *Glyceria fluitans* (L.) R.Br., and *Schoenoplectus lacustris* (L.) Palla). Alien species (e.g., *Artemisia verlotiorum* Lamotte, *Amaranthus retroflexus* L., and *Datura stramonium* L.) are abundant due to the high anthropogenic influence. By contrast, the Italian endemics are scarce. Among them, *Crocus etruscus* Parl. is included in several lists of threatened plant species. This species is a geophyte endemic to Tuscany, Umbria, and Emilia-Romagna. It grows in forests and at forest edges or, less frequently, on grasslands, from 200 to 800 m a.s.l. It flowers between February and April. In our study area, the species was found in deciduous woods with *Castanea sativa* Mill., *Quercus cerris* L., *Q. pubescens* Willd. subsp. *pubescens*, and *Q. robur* L. subsp. *robur*. The populations are not subjected to particular threats, except for a pressure exerted by wild ungulates or human foraging (Ercole et al. 2016).

The presence of endemics and species of conservation concern, both nationally and locally, is useful to assess the status and quality of a flora and of the environment. As mentioned, in our study area such species are very few. This is predominantly linked to the high human impact but might also be due to the lack of specific substrates, morphology or any other particular environmental features. For example, the Piana di Rosia lacks areas with outcropping rocks. This deficiency is partially compensated by the presence of dry-stone walls, boulders, dirt roads, and road edges. Here, we found characteristic species of outcrops or habitats with low soil formation, such as *Cerastium*

sp. pl., *Cymbalaria muralis* G.Gaertn., B.Mey. & Scherb., *Sedum* sp. pl., and *Veronica cymbalaria* Bodard. Even though such areas are limited and small in size, they host numerous species.

The alien species we found are mostly neophytes and their amount is considerable, with every tenth species being an alien one. The local naturalization status of such taxa mostly matches their status on a regional level, except for a few species that are considered casual or naturalized in the study area, but that are naturalized or invasive in Tuscany, respectively, such as *Abutilon theophrasti* Medik., *Fagopyrum esculentum* Moench, *Helianthus tuberosus* L., *Mirabilis jalapa* L., and *Oxalis articulata* Savigny. Despite the relatively high presence of alien species in the Piana di Rosia, not many species behave as invasive when compared with the whole Italian flora (Galasso et al. 2018a). The most invasive herbaceous species are *Amaranthus* sp. pl., *Erigeron* sp. pl., and *Paspalum distichum* L., while the most invasive woody aliens are *Ailanthus altissima* (Mill.) Swingle, *Parthenocissus quinquefolia* (L.) Planch., and *Robinia pseudoacacia* L. Some of them, namely *A. altissima*, *Amaranthus* sp. pl., *Erigeron* sp. pl., and *R. pseudoacacia*, are very frequent and well-established aliens in Italy, and very common in different plant communities (Viciani et al. 2020). Moreover, *R. pseudoacacia* and *A. altissima* have a heavy impact on natural habitats in the study area, mirroring what is reported at the national scale (Radtke et al. 2013; Lazzaro et al. 2020).

In the study area, we found new alien species for the administrative province of Siena. Among the most invasive ones, there are *Amaranthus hybridus* subsp. *cruentus* (L.) Thell. and *A. powellii* S.Watson. This is consistent with the invasive character of many species of the genus *Amaranthus* and with their relevance as agricultural weeds (Iamonico 2015). We also found scarcely observed aliens for the administrative province of Siena, such as *Abutilon theophrasti* Medik., *Datura stramonium* L., and *Erigeron annuus* (L.) Desf., and interesting floristic records such as *Populus canescens* (Aiton) Sm. This species grows in riparian woods and humid environments (Pignatti et al. 2017–2019). The discovery of this new phanerophyte for the province of Siena is relevant in the context of the woody flora of Tuscany (Roma-Marzio et al. 2016). The rediscovery of *Allium longispathum* Redouté, *Bromus commutatus* Schrad. subsp. *commutatus*, and *Persicaria maculosa* Gray confirms the importance of complete floristic surveys, since these taxa are likely commonly distributed, but scarcely observed. The record of *Lythrum tribracteatum* Salzm. ex Spreng. is the third record for the province of Siena. Its occurrence was previously known at Chiusi and Montepulciano Lakes (Arrigoni and Ricceri 1981). Similarly, *Conium maculatum* L. subsp. *maculatum* was reported in recent times at only a few sites in the south of the Siena province (Selvi 1996). We found other relatively rare species such as *Isatis tinctoria* L. subsp. *tinctoria*, rare in Tuscany (Peruzzi et al. 2017c). Some species new to the province of Siena, such as *Fragaria viridis* Weston subsp. *viridis* and *Spergularia rubra* (L.) J.Presl & C.Presl, are common in Tuscany, but not in the province of Siena, where they are, however, likely to be scarcely observed.

The analysis of segetal species revealed that most of the taxa are not of conservation concern in Europe, since all are common and widespread. This is consistent with the

fact that agriculture in the area is mostly intensive, and thus there is a lack of the typical species-rich fields common in many traditional agricultural areas of Italy (Fanfarillo et al. 2019b; Fanfarillo et al. 2020b). Practices such as chemical weeding and fertilization, that feature the intensively managed arable fields of Piana di Rosia, cause a reduction of segetal biodiversity (Richner et al. 2015; Fanfarillo et al. 2019a). The only exception is represented by *Legousia speculum-veneris* (L.) Chaix subsp. *speculum-veneris*, which is considered of conservation concern at the European level. This species is in fast regression under the pressure of intensive agriculture, like other segetal species (Storkey et al. 2012; Richner et al. 2015). However, *L. speculum-veneris* (L.) Chaix subsp. *speculum-veneris* is relatively common in the Italian peninsula.

Conclusions and implications for conservation

This work contributes to the knowledge of the vascular flora of a poorly studied area of southern Tuscany, a former wetland of the previous century. Our results suggest that the land-use changes that occurred in the Piana di Rosia have modified the typical wetland flora and caused a general simplification of the plant species present. Further, the overall number of species and the number of native species present is lower than expected, while the opposite is true for alien species. Despite this, remnants of natural or semi-natural vegetation, like residual woods and shrubs, together with the presence of natural and artificial small water bodies, allow the presence of interesting plant species occurring in relatively undisturbed habitats, such as endemics, relatively rare species, protected species, and hydrophytes. We also found some species that have not been reported in the administrative province of Siena for over a century. These features are typical of "type 2" of the High Nature Value farmlands, i.e., "farmlands with a mosaic of low intensity agriculture and natural and structural elements, such as field margins, hedgerows, stone walls, patches of woodland or scrub, small rivers etc." (Keenleyside et al. 2014). However, the Piana di Rosia is currently not qualifiable as a High Nature Value farmland due to the intensive land use. In this context, the most biologically valuable areas are ecological corridors bordering channels, streams, ditches, residual groves, highlighting the problem of the reduced surface of these elements and a generalized habitat fragmentation. Residual wetlands within agroecosystems should be maintained, as they offer fundamental niches for numerous hygrophilous species, suggesting that many relevant species might be commonly overlooked, also in areas with a currently scarce natural importance.

Although this study fills a gap in the floristic knowledge of southern Tuscany, our data also suggest that the knowledge of southern Tuscany is far from complete and further botanical and ecological investigations are generally needed, also in areas with an alleged scarce environmental value. Accordingly, surveying and inventorying plant biodiversity in current agroecosystems is fundamental for what they have represented in the past, but also for a better application of sustainable management in the future, in the perspective of preserving valuable elements and restore ecosystem functioning and services (Zerbe 2019). Our findings suggest that an ecological intensification of

the agroecosystem would be feasible in the area thanks to the remnants of naturalness present. Also, native plant material could be used to increase the extent and quality of natural and semi-natural elements in the agricultural mosaic. This would help to make such remnants more valuable, also considering that restoration of these agroecosystems becomes much more difficult once they have disappeared (Strohbach et al. 2015). From a conservation point of view, the natural value of this agricultural area could be enhanced, and its current management partly reconsidered, in order to maintain the remnants of floristic naturalness present, bearing also in mind that almost half of the Piana di Rosia borders on protected areas. Lastly, we recall that floristic surveys should become a basic tool for policymakers to calibrate their environment-related decisions.

Acknowledgements

We thank Nicola M.G. Ardenghi and Gabriele Galasso for their help in the identification of some plants, Barbara Anselmi for the help in creating the maps, Ivan Martini for revising the section about geologic aspects, Silvia Cannucci for the help during field surveys, Oretta Muzzi for her help with obtaining poorly accessible literature and the Ampugnano Airport for allowing us to enter the fenced area. We thank Fabrizio Bartolucci, Stefania Biondi and Lorenzo Peruzzi for their comments on the manuscript. G.B. was supported by the Accademia dei Fisiocritici of Siena.

References

Alessandrini A (2000) La flora delle zone umide d'acqua dolce: importanza e problemi di conservazione. In: Bernardoni A, Casale F (Eds) Proceedings of the conference "Zone umide d'acqua dolce – Tecniche e strategie di gestione della vegetazione palustre". Quaderni della Riserva Naturale Paludi di Ostiglia 1: 11–19.

Angiolini C, Arrigoni PV, Selvi F (2005) Stato attuale e progressi delle conoscenze floristiche in Toscana dal 1978 ad oggi. In: Scoppola A, Blasi C (Eds) Stato attuale delle conoscenze sulla flora vascolare d'Italia. Palombi, Roma, 141–145.

Angiolini C, Nucci A, Frignani F, Landi M (2011) Using multivariate analyses to assess effects of fluvial type on plant species distribution in a Mediterranean river. Wetlands 31(1): 167–177. https://doi.org/10.1007/s13157-010-0118-7

Angiolini C, Viciani D, Bonari G, Zoccola A, Bottacci A, Ciampelli P, Gonnelli V, Lastrucci L (2019) Environmental drivers of plant assemblages: are there differences between palustrine and lacustrine wetlands? A case study from the northern Apennines (Italy). Knowledge and Management of Aquatic Ecosystems 420(34): 1–11. https://doi.org/10.1051/kmae/2019026

Arrigoni PV (1981) Introduzione al convegno sulle zone umide della Toscana tenutosi in Pisa il 20 Ottobre 1980. Atti della Società Toscana di Scienze Naturali. Memorie Serie B 88: 279–284.

Arrigoni PV (2014) Revisione tassonomica e corologica del genere *Polygala* in Italia. Informatore Botanico Italiano 46(2): 235–263.

Arrigoni PV (2016) Flora analitica della Toscana (Vol. 1). Polistampa, Firenze, 408 pp.
Arrigoni PV (2017) Flora analitica della Toscana (Vol. 2). Polistampa, Firenze, 336 pp.
Arrigoni PV (2018) Flora analitica della Toscana (Vol. 3). Polistampa, Firenze, 536 pp.
Arrigoni PV, Ricceri C (1981) La vegetazione dei laghi di Chiusi e di Montepulciano (Siena). Atti della Società Toscana di Scienze Naturali – Memorie Serie B 88: 285–299.
Barazzuoli P, Migliorini J, Capacci F (2020) Water resources and main groundwater bodies in the Province of Siena in the framework of the land management plan. Italian Journal of Groundwater 9(1): 51–61. https://doi.org/10.7343/as-2020-433
Baroni E (1908) Supplemento Generale al Prodromo della Flora Toscana di T. Caruel. Società Botanica Italiana, Firenze, 638 pp.
Bartolucci F, Peruzzi L, Galasso G, Albano A, Alessandrini A, Ardenghi NMG, Astuti G, Bacchetta G, Ballelli S, Banfi E, Barberis G, Bernardo L, Bouvet D, Bovio M, Cecchi L, Di Pietro R, Domina G, Fascetti S, Fenu G, Festi F, Foggi B, Gallo L, Gottschlich G, Gubellini L, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin R, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Conti F (2018a) An updated checklist of the vascular flora native to Italy. Plant Biosystems 152(2): 179–303. https://doi.org/10.1080/11263504.2017.1419996
Bartolucci F, Domina G, Ardenghi NMG, Banfi E, Bernardo L, Bonari G, Buccomino G, Calvia G, Carruggio F, Cavallaro V, Chianese G, Conti F, Facioni L, Del Vico E, Di Gristina E, Falcinelli F, Forte L, Gargano D, Mantino F, Martino M, Mei G, Mereu G, Olivieri N, Passalacqua NG, Pazienza G, Peruzzi L, Roma-Marzio F, Scafidi F, Scoppola A, Stinca A, Nepi C (2018b) Notulae to the Italian native vascular flora: 5. Italian Botanist 5: 71–81. https://doi.org/10.3897/italianbotanist.5.25892
Bartolucci F, Domina G, Ardenghi NMG, Bacchetta G, Bernardo L, Buccomino G, Buono S, Caldararo F, Calvia G, Carruggio F, Cavagna A, D'Amico FS, Di Carlo F, Festi F, Forte L, Galasso G, Gargano D, Gottschlich G, Lazzaro L, Magrini S, Maiorca G, Medagli P, Mei G, Mennini F, Mereu G, Miserocchi D, Olivieri N, Passalacqua NG, Pazienza G, Peruzzi L, Prosser F, Rempicci M, Roma-Marzio F, Ruggero A, Sani A, Saulle D, Steffanini C, Stinca A, Terzi M, Tondi G, Trenchi M, Viciani D, Wagensommer RP, Nepi C (2018c) Notulae to the Italian native vascular flora: 6. Italian Botanist 6: 45–64. https://doi.org/10.3897/italianbotanist.6.30575
Bilz M, Kell SP, Maxted N, Lansdown RV [Eds] (2011) European Red List of vascular plants. Publications Office of the European Union, Luxembourg.
Bonari G, Cantini D, Angiolini C, Selvi F, Scoppola A, Viciani D, Ferretti G, Gabellini A, Perini C, De Dominicis V, Ardenghi NMG, Lastrucci L (2016) Contribution to the vascular flora of Pietraporciana Nature Reserve (Southern Tuscany, Italy). Atti della Società Toscana di Scienze Naturali – Memorie Serie B 123: 9–28. http://dx.doi.org/10.2424/ASTSN.M.2016.02
Bonari G, Selvi F, Minniti F, Frignani F, Angiolini C (2018) Contribution to the vascular flora of Castelvecchio Nature Reserve (central Tuscany, Italy). Atti della Società Toscana di Scienze Naturali – Memorie Serie B 125: 77–86. https://doi.org/10.3897/italianbotanist.7.33763

Bonari G, Fiaschi T, Chytrý K, Biagioli M, Angiolini C (2019) *Coriaria myrtifolia*-dominated vegetation: Syntaxonomic considerations on a newly found community type in Tuscany (Italy). Plant Sociology 56(2): 99–112. https://doi.org/10.7338/pls2019562/07

Cannucci S, Angiolini C, Anselmi B, Banfi E, Biagioli E, Castagnini P, Centi C, Fiaschi T, Foggi B, Gabellini A, Lastrucci L, Lattanzi E, Scoppola A, Selvi F, Viciani D, Bonari G (2019) Contribution to the knowledge of the vascular flora of Miniere di Murlo area (southern Tuscany, Italy). Italian Botanist 7: 51–67. https://doi.org/10.3897/italianbotanist.7.33763

Carta A, Peruzzi L (2011) *Crocus etruscus*. The IUCN Red List of Threatened Species 2011: e.T161939A5516365. [accessed 11.01.2021]

Caruel T (1860) Prodromo della flora toscana. Le Monnier, Firenze, 767 pp.

Castelli C [Ed.] (2012) RENATO – Repertorio Naturalistico Toscano. Aggiornamento dei dati per il periodo 2005–2010. Technical Report for the Tuscany Region.

Castroviejo S, Aedo C, Ciruiano S, Lainz M, Montserrat P, Morales R, Muñoz Garmendia F, Navarro C, Paiva J, Soriano C [Eds] (1984–2005) Flora Iberica. Real Jardìn Botanico, CSIC, Madrid.

Chiarucci A, Mariotti MG, De Dominicis V (1993) Ricerche geobotaniche in Val di Merse (Toscana meridionale). 4. Contributo alla conoscenza della Flora della Val di Farma. Webbia 47(2): 277–311. https://doi.org/10.1080/00837792.1993.10670546

Di Natale S, Lastrucci L, Hroudová Z, Viciani D (2020) A review of *Bolboschoenus* species (Cyperaceae) in Italy based on herbarium data. Plant Biosystems. https://doi.org/10.1080/11263504.2020.1852330

D'Antraccoli M, Roma-Marzio F, Carta A, Landi S, Bedini G, Chiarucci A, Peruzzi L (2019) Drivers of floristic richness in the Mediterranean: a case study from Tuscany. Biodiversity and Conservation 28: 1411–1429. https://doi.org/10.1007/s10531-019-01730-x

Environmental Protection Agency (2020) Wetlands Protection and Restoration. [accessed 11.01.2021]

Ercole S, Giacanelli V, Bacchetta G, Fenu G, Genovesi P [Eds] (2016) Manuali per il monitoraggio di specie e habitat di interesse comunitario (Direttiva 92/43/CEE) in Italia: specie vegetali. ISPRA, Serie Manuali e linee guida, 140/2016.

Fanfarillo E, Kasperski A, Giuliani A, Abbate G (2019a) Shifts of arable plant communities after agricultural intensification: A floristic and ecological diachronic analysis in maize fields of Latium (central Italy). Botany Letters 166(3): 356–365. https://doi.org/10.1080/23818107.2019.1638829

Fanfarillo E, Scoppola A, Lososová Z, Abbate G (2019b) Segetal plant communities of traditional agroecosystems: a phytosociological survey in central Italy. Phytocoenologia 49(2): 165–183. https://doi.org/10.1127/phyto/2019/0282

Fanfarillo E, Latini M, Iberite M, Bonari G, Nicolella G, Rosati L, Salerno G, Abbate G (2020a) The segetal flora of winter cereals and allied crops in Italy: species inventory with chorological, structural and ecological features. Plant Biosystems 154(6): 935–946. https://doi.org/10.1080/11263504.2020.1739164

Fanfarillo E, Petit S, Dessaint F, Rosati L, Abbate G (2020b) Species composition, richness, and diversity of weed communities of winter arable land in relation to geo-environmen-

tal factors: A gradient analysis in mainland Italy. Botany 98(7): 381–392. https://doi.org/10.1139/cjb-2019-0178

Favilli L, Benocci A, Piazzini S, Manganelli G (2017) Il Padule di Rosia: un ambiente da ripristinare. EtruriaNatura XII: 108–116.

Fiori A (1923–1929) Nuova Flora Analitica d'Italia (Vols. 1–3). Tipografia M. Ricci, Firenze.

Galasso G, Conti F, Peruzzi L, Ardenghi NMG, Banfi E, Celesti-Grapow L, Albano A, Alessandrini A, Bacchetta G, Ballelli S, Bandini Mazzanti M, Barberis G, Bernardo L, Blasi C, Bouvet D, Bovio M, Cecchi L, Del Guacchio E, Domina G, Fascetti S, Gallo L, Gubellini L, Guiggi A, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Marchetti D, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Podda L, Poldini L, Prosser F, Raimondo FM, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna S, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Bartolucci F (2018a) An updated checklist of the vascular flora alien to Italy. Plant Biosystems 152(3): 556–592. https://doi.org/10.1080/11263504.2018.1441197

Galasso G, Domina G, Adorni M, Ardenghi NMG, Bonari G, Buono S, Cancellieri L, Chianese G, Ferretti G, Fiaschi T, Forte L, Guarino R, Labadessa R, Lastrucci L, Lazzaro L, Magrini S, Minuto L, Mossini S, Olivieri N, Scoppola A, Stinca A, Turcato C, Nepi C (2018b) Notulae to the Italian alien vascular flora: 5. Italian Botanist 5: 45–56. https://doi.org/10.3897/ib.5.25910

Galasso G, Domina G, Alessandrini A, Ardenghi NMG, Bacchetta G, Ballelli S, Bartolucci F, Brundu G, Buono S, Busnardo G, Calvia G, Capece P, D'Antraccoli M, Di Nuzzo L, Fanfarillo E, Ferretti G, Guarino R, Iamonico D, Iberite M, Latini M, Lazzaro L, Lonati M, Lozano V, Magrini S, Mei G, Mereu G, Moro A, Mugnai M, Nicolella G, Nimis PL, Olivieri H, Pennesi R, Peruzzi L, Podda L, Probo M, Prosser F, Ravetto Enri S, Roma-Marzio F, Ruggero A, Scafidi F, Stinca A, Nepi C (2018c) Notulae to the Italian alien vascular flora: 6. Italian Botanist 6: 65–90. https://doi.org/10.3897/italianbotanist.6.30560

Gardner RC, Barchiesi S, Beltrame C, Finlayson CM, Galewski T, Harrison I, Paganini M, Perennou C, Pritchard DE, Rosenqvist A, Walpole M (2015) State of the World's wetlands and their services to people: a compilation of recent analyses. Ramsar Convention Secretariat, Gland. Ramsar Briefing Note no. 7: 1–21. https://doi.org/10.2139/ssrn.2589447

Gigante D, Attorre F, Venanzoni R, Acosta ATR, Agrillo E, Aleffi M, Alessi N, Allegrezza M, Angelini P, Angiolini C, Assini S, Azzella MM, Bagella S, Biondi E, Bolpagni R, Bonari G, Bracco F, Brullo S, Buffa G, Carli E, Caruso G, Casavecchia S, Casella L, Cerabolini BEL, Ciaschetti G, Copiz R, Cutini M, Del Vecchio S, Del Vico E, Di Martino L, Facioni L, Fanelli G, Foggi B, Frattaroli AR, Galdenzi D, Gangale C, Gasparri R, Genovesi P, Gianguzzi L, Gironi F, Giusso Del Galdo G, Gualmini M, Guarino R, Lasen C, Lastrucci L, Maneli F, Pasta S, Paura B, Perrino EV, Petraglia A, Pirone G, Poponessi S, Prisco I, Puglisi M, Ravera S, Sburlino G, Sciandrello S, Selvaggi A, Spada F, Spampinato G, Strumia S, Tomaselli M, Tomaselli V, Uzunov D, Viciani D, Villani M, Wagensommer RP, Zitti S (2016) A methodological protocol for Annex I Habitats monitoring: the contribution of Vegetation science. Plant Sociology 53(2): 77–87. https://doi.org/10.7338/pls2016532/06

Gigante D, Acosta ATR, Agrillo E, Armiraglio S, Assini S, Attorre F, Bagella S, Buffa G, Casella L, Giancola C, Giusso Del Galdo GP, Marcenò C, Pezzi G, Prisco I, Venanzoni R, Viciani

D (2018) Habitat conservation in Italy: the state of the art in the light of the first European Red List of Terrestrial and Freshwater Habitats. Rendiconti Lincei. Scienze Fisiche e Naturali 29(2): 251–265. https://doi.org/10.1007/s12210-018-0688-5

Greppi C (2014) La Piana di Rosia dalla fine del governo granducale alla crisi della mezzadria. La Piana di Rosia (Sovicille): storia di un paesaggio culturale di pianura. Miscellanea storica della Valdelsa 326(1): 115–131.

Hunter ML, Gibbs JP (2007) Fundamentals of conservation biology (3rd ed.). Blackwell Publishing, Oxford.

Iacoviello F, Martini I (2012) Provenance and geological significance of red mud and other clastic sediments of the Mugnano cave (Montagnola Senese, Italy). International Journal of Speleology 41(2): 317–328. https://doi.org/10.5038/1827-806X.41.2.17

Iacoviello F, Martini I (2013) Clay minerals in cave sediments and terra rossa soils in the Montagnola Senese karst massif (Italy). Geological Quarterly 57(3): 527–536. https://doi.org/10.7306/gq.1111

Iamonico D (2015) Taxonomic revision of the genus *Amaranthus* (Amaranthaceae) in Italy. Phytotaxa 199(1): 1–84. https://doi.org/10.11646/phytotaxa.199.1.1

IUCN (2021) The IUCN Red List of Threatened Species. Version 2020-3. [accessed 11.01.2021]

Janssen J, Rodwell J, García Criado M, Gubbay S, Haynes T, Nieto A, Sanders N, Landucci F, Loidi J, Ssymank A, Tahvanainen T, Valderrabano M, Acosta A, Aronsson M, Arts G, Attorre F, Bergmeier E, Bijlsma R-J, Bioret F, Gubbay S (2016) European Red List of Habitats – Part 2. Terrestrial and freshwater habitats.

Keenleyside C, Beaufoy G, Tucker G, Jones G (2014) High Nature Value farming throughout EU-27 and its financial support under the CAP. Institute for European Environmental Policy, London.

Landi M, Angiolini C, De Dominicis V (2002) Florula del tratto medio-basso del fiume Merse (Toscana meridionale). Micologia e Vegetazione Mediterranea 17(2): 175–192.

Landi M, Bonari G, Frignani F, Landi S, Angiolini C (2016) La flora della Riserva Naturale Biogenetica di Tocchi. In: Saveri C (Ed.) La Riserva Naturale Biogenetica di Tocchi. Il Leccio, Monteriggioni, 135–160.

Landi M, Frignani F, Bonini I, Casini F, Saveri C, De Dominicis V, Angiolini C (2009) Flora and vegetation in the catchment area of the stream "La Bolza" in the Merse valley (Siena, southern Tuscany). Webbia 64(2): 187–212. https://doi.org/10.1080/00837792.2009.10670859

Lastrucci L, Bonari G, Angiolini C, Landi M, Casini F, Giallonardo T, Landucci F, Gigante D, Venanzoni R, Viciani D (2014) Vegetation of Lakes Chiusi and Montepulciano (Tuscany, Central Italy): updated knowledge and new discoveries. Plant Sociology 51(2): 29–55. https://doi.org/10.7338/pls2014512/03

Lastrucci L, Landi M, Angiolini C (2010) Vegetation analysis on wetlands in a Tuscan agricultural landscape (central Italy). Biologia 65(1): 54–68. https://doi.org/10.2478/s11756-009-0213-5

Lazzaro L, Bolpagni R, Buffa G, Gentili R, Lonati M, Stinca A, Acosta ATR, Adorni M, Aleffi M, Allegrezza M, Angiolini C, Assini S, Bagella S, Bonari G, Bovio M, Bracco F, Brundu G, Caccianiga M, Carnevali L, Di Cecco V, Ceschin S, Ciaschetti G, Cogoni A, Foggi B, Frattaroli AR, Genovesi P, Gigante D, Lucchese F, Mainetti A, Mariotti M, Minissale P, Paura B, Pellizzari M, Perrino EV, Pirone G, Poggio L, Poldini L, Poponessi S, Prisco I,

Prosser F, Puglisi M, Rosati L, Selvaggi A, Sottovia L, Spampinato G, Stanisci A, Venanzoni R, Viciani D, Vidali M, Villani M, Lastrucci L (2020) Impact of invasive alien plants on native plant communities and Nature Natura 2000 habitats: state of the art, gap analysis and perspectives in Italy. Journal of Environmental Management 274: e111140. https://doi.org/10.1016/j.jenvman.2020.111140

Mariotti M, Persiano T, Regni E, De Dominicis V (1986) Ricerche geobotaniche in Val di Merse (Toscana meridionale). I. Contributo alla conoscenza della flora di Pian di Feccia e Pian Ferrale. Webbia 39(2): 233–258. https://doi.org/10.1080/00837792.1986.10670372

Martellos S, Bartolucci F, Conti F, Galasso G, Moro A, Pennesi R, Peruzzi L, Pittao E, Nimis PL (2020) FlorItaly – the portal to the Flora of Italy. PhytoKeys 156: 55–71. https://doi.org/10.3897/phytokeys.156.54023

Martini I (2011) Cave clastic sediments and implications for speleogenesis: new insights from the Mugnano Cave (Montagnola Senese, Northern Apennines, Italy). Geomorphology 134(3–4): 452–460. https://doi.org/10.1016/j.geomorph.2011.07.024

Mediterranean Wetlands Observatory (2014) Land cover – Spatial dynamics in Mediterranean coastal wetlands from 1975 to 2005. Thematic collection, issue #2. Tour du Valat.

Orsenigo S, Fenu G, Gargano D, Montagnani C, Abeli T, Alessandrini A, Bacchetta G, Bartolucci F, Carta A, Castello M, Cogoni D, Conti F, Domina G, Foggi B, Gennai M, Gigante D, Iberite M, Peruzzi L, Pinna M, Rossi G (2020) Red list of threatened vascular plants in Italy. Plant Biosystems. https://doi.org/10.1080/11263504.2020.1739165

Peruzzi L, Bedini G [Eds] (2015 onwards) Wikiplantbase #Toscana v. 2.1. [accessed 11.01.2021]

Peruzzi L, Bagella S, Filigheddu S, Pierini B, Sini M, Roma-Marzio F, Caparelli KF, Bonari G, Gestri G, Dolci D, Consagra A, Sassu P, Caria MC, Rivieccio G, Marrosu M, D'Antraccoli M, Pacifico G, Piu V, Bedini G (2017a) The Wikiplantbase project: the role of amateur botanists in building up large online floristic databases. Flora Mediterranea 27: 117–129. https://doi.org/10.7320/FlMedit27.117

Peruzzi L, Viciani D, Agostini N, Angiolini C, Ardenghi NMG, Astuti G, Bardaro MR, Bertacchi A, Bonari G, Boni S, Chytrý M, Ciampolini F, D'Antraccoli M, Domina G, Ferretti G, Guiggi A, Iamonico D, Laghi P, Lastrucci L, Lazzaro L, Lazzeri V, Liguori P, Mannocci M, Marsiaj G, Novák P, Nucci A, Pierini B, Roma-Marzio F, Romiti B, Sani A, Zoccola A, Zukal D, Bedini G (2017b) Contributi per una flora vascolare di Toscana. VIII (440–506). Atti della Società Toscana di Scienze Naturali – Memorie Serie B 123: 71–82. https://doi.org/10.2424/ASTSN.M.2016.06

Peruzzi L, Viciani D, Angiolini C, Astuti G, Banfi E, Benocci A, Bonari G, Bruni G, Caramante P, Caré M, Carta A, Castagnini P, Cheli A, Ciampolini F, D'Antraccoli M, Ferretti G, Ferruzzi S, Fiaschi T, Foggi B, Fontana D, Galasso G, Gallo L, Galvani D, Gestri G, Grazzini A, Lastrucci L, Lazzaro L, Loppi S, Manganelli G, Mugnai M, Piazzini S, Pierini B, Roma-Marzio F, Sani A, Selvi F, Soldano A, Stinca A, Bedini G (2017c) Contributi per una flora vascolare di Toscana. IX (507–605). Atti della Società Toscana di Scienze Naturali – Memorie Serie B 124: 73–86. https://doi.org/10.2424/ASTSN.M.2017.07

Peruzzi L, Viciani D, Angiolini C, Astuti G, Banfi E, Bardaro MR, Bianchetto E, Bonari G, Cannucci S, Cantini D, Castagnini P, D'Antraccoli M, Esposito A, Ferretti G, Fiaschi T, Foggi B, Franceschi G, Galasso G, Gottschlich G, Lastrucci L, Lazzaro L, Maneli F, Mar-

chetti D, Marsiaj G, Mugnai M, Roma-Marzio F, Ruocco M, Salvai G, Stinca A, Bedini G (2018) Contributi per una flora vascolare di Toscana. X (606–663). Atti della Società Toscana di Scienze Naturali – Memorie Serie B 125: 67–76. https://doi.org/10.2424/ASTSN.M.2018.12

Pesaresi S, Galdenzi D, Biondi E, Casavecchia S (2014) Bioclimate of Italy: application of the worldwide bioclimatic classification system. Journal of Maps 10(4): 538–553. https://doi.org/10.1080/17445647.2014.891472

Pesaresi S, Biondi E, Casavecchia S (2017) Bioclimates of Italy. Journal of Maps 13(2): 955–960. https://doi.org/10.1080/17445647.2017.1413017

Pignatti S (1982) Flora d'Italia (Vols. 1–3). Edagricole, Bologna.

Pignatti S, Guarino R, La Rosa M (2017–2019) Flora d'Italia (Ed. 2, Vols. 1–4). Edagricole di New Business Media, Milano.

Portal to the Flora of Italy (2020 onwards) Portale della Flora d'Italia/Portal to the Flora of Italy. 2020.1. [accessed 11.01.2021]

Radtke A, Ambraß S, Zerbe S, Tonon G, Fontana V, Ammer C. (2013) Traditional coppice forest management drives the invasion of *Ailanthus altissima* and *Robinia pseudoacacia* into deciduous forests. Forest Ecology and Management 291: 308–317. https://doi.org/10.1016/j.foreco.2012.11.022

R Core Team (2020) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. [accessed 11.01.2021]

Regione Toscana (2020) GEOscopio. [accessed 11.01.2021]

Rameau JC, Mansion D, Dumé G, Timbal J, Lecointe A, Dupont P, Keller R (1989) Flore Forestière Francaise. Guide Ecologique Illustré. Institut pour le Développement Forestier & Ministère de l'Agricolture et de la Foret.

Rameau JC, Mansion D, Dumé G, Gauberville C, Bardat J, Bruno E, Keller R (2008) Flore Forestière Francaise. Guide Ecologique Illustré. Institut pour le Développement Forestier-CNPPF & Ministère de l'Agricolture et de la Péche-DGFAR.

Ramsar Convention on Wetlands (2018) Global Wetland Outlook: State of the World's wetlands and their services to people. Ramsar Convention Secretariat, Gland.

Richner N, Holderegger R, Linder HP, Walter T (2015) Reviewing change in the arable flora of Europe: a meta-analysis. Weed Research 55: 1–13. https://doi.org/10.1111/wre.12123

Roma-Marzio F, Bedini G, Müller JV, Peruzzi L (2016) A critical checklist of the woody flora of Tuscany (Italy). Phytotaxa 287(1): 1–135. https://doi.org/10.11646/phytotaxa.287.1.1

Rossi G, Montagnani C, Gargano D, Peruzzi L, Abeli T, Ravera S, Cogoni A, Fenu G, Magrini S, Gennai M, Foggi B, Wagensommer RP, Venturella G, Blasi C, Raimondo FM, Orsenigo S [Eds] (2013) Lista Rossa della Flora Italiana. 1. Policy Species e altre specie minacciate. Comitato Italiano IUCN e Ministero dell'Ambiente e della Tutela del Territorio e del Mare, Roma.

Selvi F (1996) Flora and phytogeography of the volcanic dome of Monte Amiata (central Italy). Webbia 50(2): 265–310. https://doi.org/10.1080/00837792.1996.10670606

Sposimo P, Castelli C (2005) La biodiversità in Toscana. Specie e habitat in pericolo. Archivio del Repertorio Naturalistico Toscano (RENATO). Regione Toscana-Direzione Generale Politiche Territoriali e Ambientali, Firenze.

Storkey J, Meyer S, Still KS, Leuschner C (2012) The impact of agricultural intensification and land-use change on the European arable flora. Proceedings of the Royal Society B 279: 1421–1429. https://doi.org/10.1098/rspb.2011.1686

Strohbach MW, Kohler ML, Dauber J, Klimek S (2015) High Nature Value farming: From indication to conservation. Ecological Indicators 57: 557–563. https://doi.org/10.1016/j.ecolind.2015.05.021

Tison J-M, De Foucault B (2014) Flora Gallica: Flore de France. Biotope éditions, Mèze.

Thiers B (2020 onwards) Index Herbariorum: A Global Directory of Public Herbaria and Associated Staff. New York Botanical Garden's Virtual Herbarium. [accessed 11.01.2021]

Tomei PE (1982) Le zone umide della Toscana: stato attuale delle conoscenze geobotaniche e prospettive di salvaguardia. Atti della Società Toscana di Scienze Naturali – Memorie Serie B 89: 345–361.

Tutin TG, Heywood VH, Burgers NA, Moore DM, Valentine DH, Walters SM, Webb DA [Eds] (1964–1980) Flora Europaea (Vols. 1–5). University Press, Cambridge.

Viciani D, Lastrucci L, Dell'Olmo L, Ferretti G, Foggi B (2014) Natura 2000 habitats in Tuscany (central Italy): synthesis of main conservation features based on a comprehensive database. Biodiversity and Conservation 23: 1551–1576. https://doi.org/10.1007/s10531-014-0686-6

Viciani D, Vidali M, Gigante D, Bolpagni R, Villani M, Acosta ATR, Adorni M, Aleffi M, Allegrezza M, Angiolini C, Assini S, Bagella S, Bonari G, Bovio M, Bracco F, Brundu G, Buffa G, Caccianiga M, Carnevali L, Ceschin S, Ciaschetti G, Cogoni A, Di Cecco V, Foggi B, Frattaroli AR, Genovesi P, Gentili R, Lazzaro L, Lonati M, Lucchese F, Mainetti A, Mariotti M, Minissale P, Paura B, Pellizzari M, Perrino E, Pirone G, Poggio L, Poldini L, Poponessi S, Prisco I, Prosser F, Puglisi M, Rosati L, Selvaggi A, Sottovia L, Spampinato G, Stanisci A, Stinca A, Venanzoni R, Lastrucci L (2020) A preliminary checklist of the alien-dominated vegetation in Italy. Plant Sociology 57(1): 29–54. https://doi.org/10.3897/pls2020571/04

Zerbe S (2019) Renaturierung von Ökosystemen im Spannungsfeld von Mensch und Umwelt. Ein interdisziplinäres Fachbuch. Springer, Heidelberg. https://doi.org/10.1007/978-3-662-58650-1

Supplementary material 1

Figures S1–S3 and floristic inventory

Authors: Gianmaria Bonari, Tiberio Fiaschi, Emanuele Fanfarillo, Francesco Roma-Marzio, Simona Sarmati, Enrico Banfi, Marco Biagioli, Stefan Zerbe, Claudia Angiolini

Data type: multimedia

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/italianbotanist.11.62040.suppl1